APS Water System

05/17/05

The Advanced Photon Source (APS) maintains a revolving beam of X-ray generating electrons at almost the speed of light within a spatial stability of approximately 1 micron inside an aluminum vacuum chamber. In order to achieve such a stringent operating condition, the APS water cooling system uses a very pure (ASTM grade-I) water and needs to operate undisturbed and reliably while maintaining a maximum temperature fluctuation of ±0.2°F to ±0.05° F. Deionised (DI) water is needed to prevent current leakage from electromagnets while it passes through the current carrying copper tubing contained within these magnets.

The cooling water distribution system is designed to water cool various critical components located at linac, booster, storage ring (SR) etc. It is mainly divided into two subdivisions namely Primary and Secondary water system. The Primary water system is located in the Utility building while the secondary system is located at the Storage Ring (SR) mezzanine, outboard of the experimental floor.

A third separate cooling system is also located at the mezzanine floor that cools the aluminum vacuum chamber in the storage ring. The stability of the electron beam inside vacuum chamber requires the temperature fluctuation of this third cooling water to be within ±0.05° F.

A schematic of the cooling system is shown below:

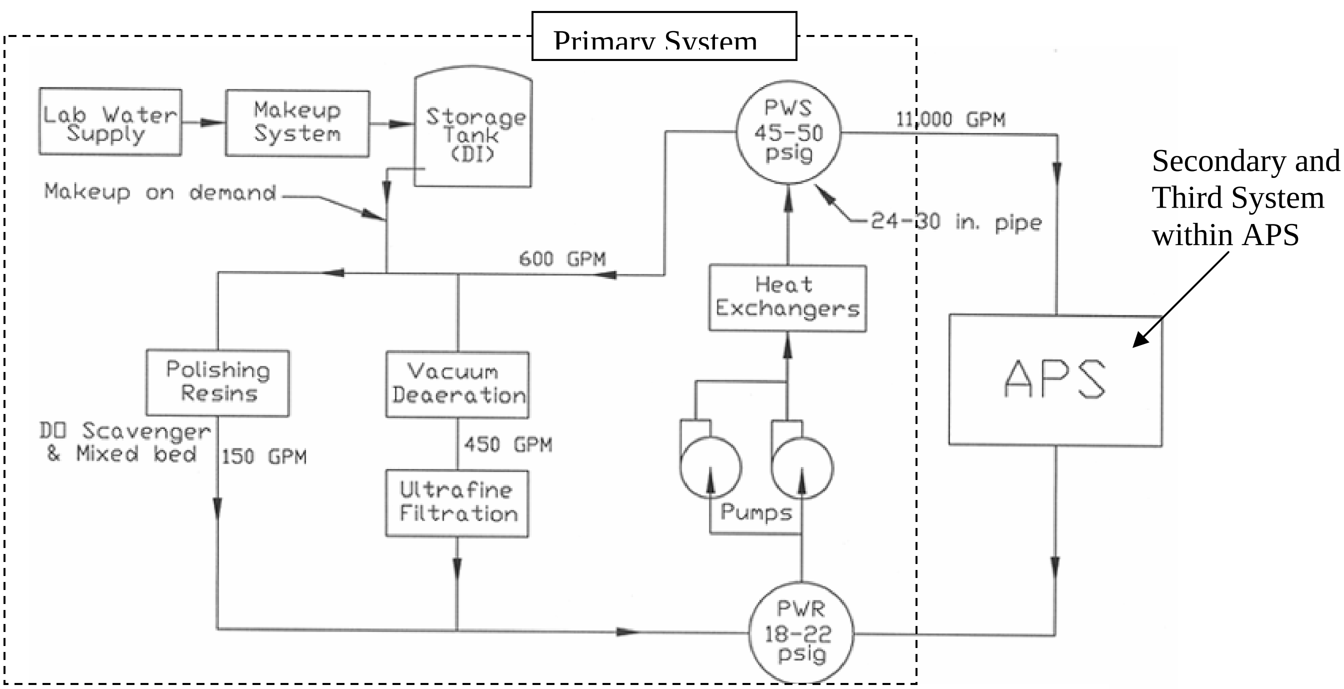

Fig 1: Block Diagram of Process Water System

The following schematic depicts the interaction between the primary and secondary system through the bridge.

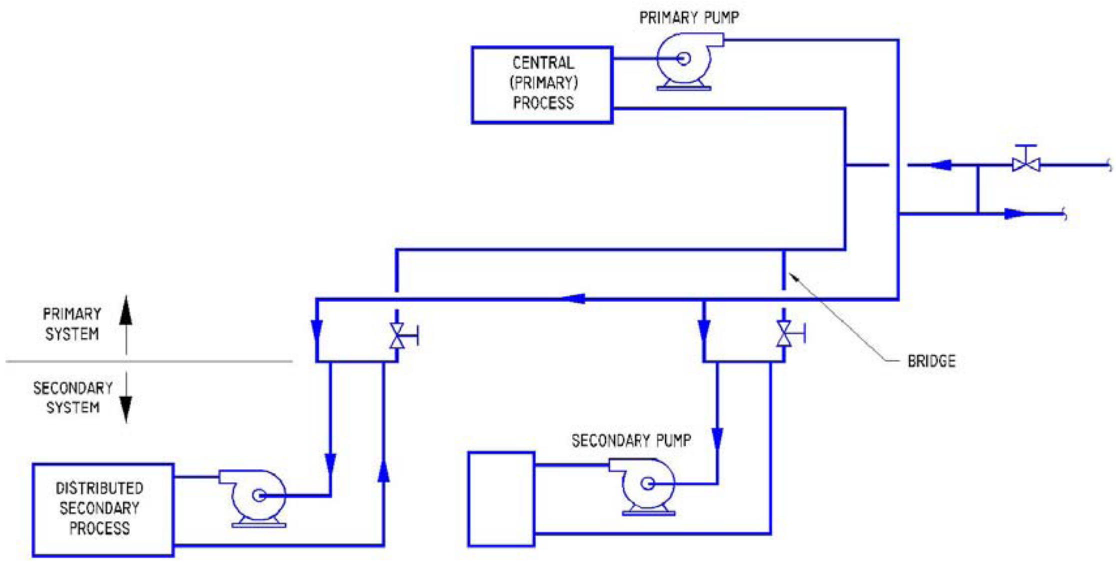

Fig 2: Schematic of the Integral Primary and Secondary System

Primary Water System:

The most important quality requirement of the cooling water is de-ionized (DI) water with negligible amount of impurity. The laboratory water comes from Lake Michigan. Deionization, degasification and filtration of this laboratory water take place at the primary water system. Heat extraction also takes place at the primary system by the heat exchangers and the chiller. The primary system that is located in the Utility building consists of heat exchangers, a centrifugal chiller and a polishing system to control the water quality to the required level of purity. There are three centrifugal distribution pumps that are connected in parallel. One of these three pumps remains on standby while the other two pumps run simultaneously. There is also a make up water system consisting of a storage tank of 6000 gal capacity which runs once or twice a day to compensate for the leaked water. Normal demand of makeup water is between 50-1000 gal/day. When the process water pressure reaches a low set point, a pump starts delivering makeup water from the tank at a rate of 150 gpm.

There are four plate and frame type heat exchangers. One of which remains on standby while the other three are operational. Warm water from the heat exchangers is cooled at the cooling towers (there are three cooling towers) by the energy efficient evaporative cooling method. When the evaporative cooling is not sufficient to cool the water to 75° F (during summer), an additional chiller is used.

The following schematic shows the arrangement of the pumps and heat exchangers in the primary (DI) water system:

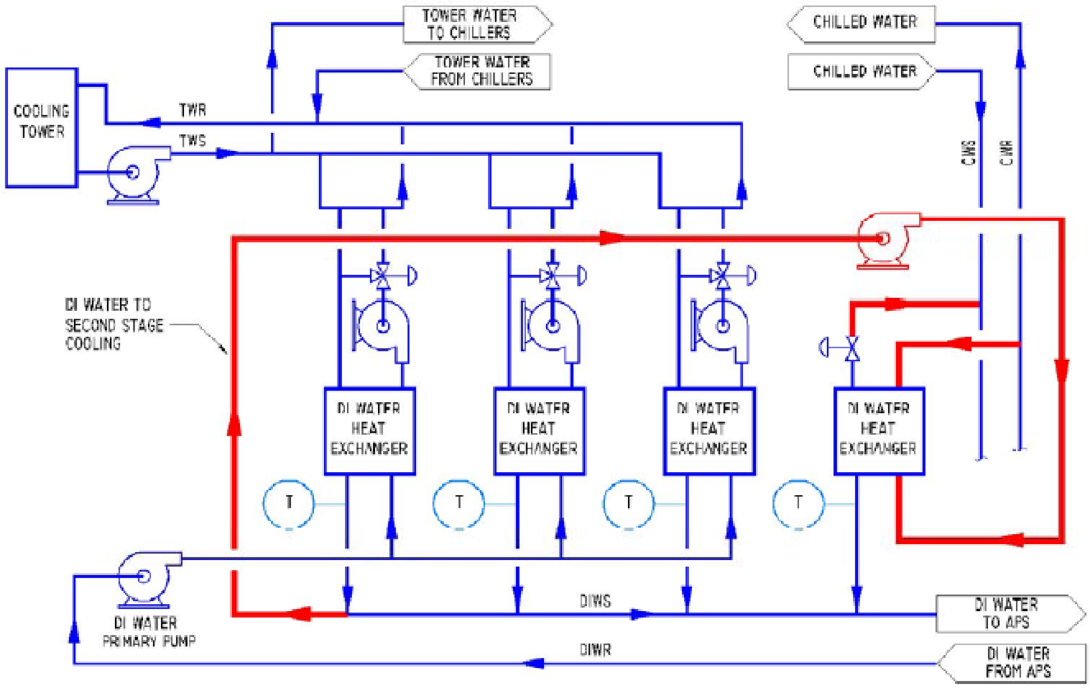

Fig 3: Schematic of DI Water Primary System

Fig 4: Process Water Heat Exchangers

Fig 5: Process Water Chillers

Fig 6: Primary Process Water Pumps

Fig 7: Process Water Storage Tank and Pumps

The polishing system consists of a vacuum degassifier, resin beds, an ultra violet light treatment and a filter of 0.5 micron.

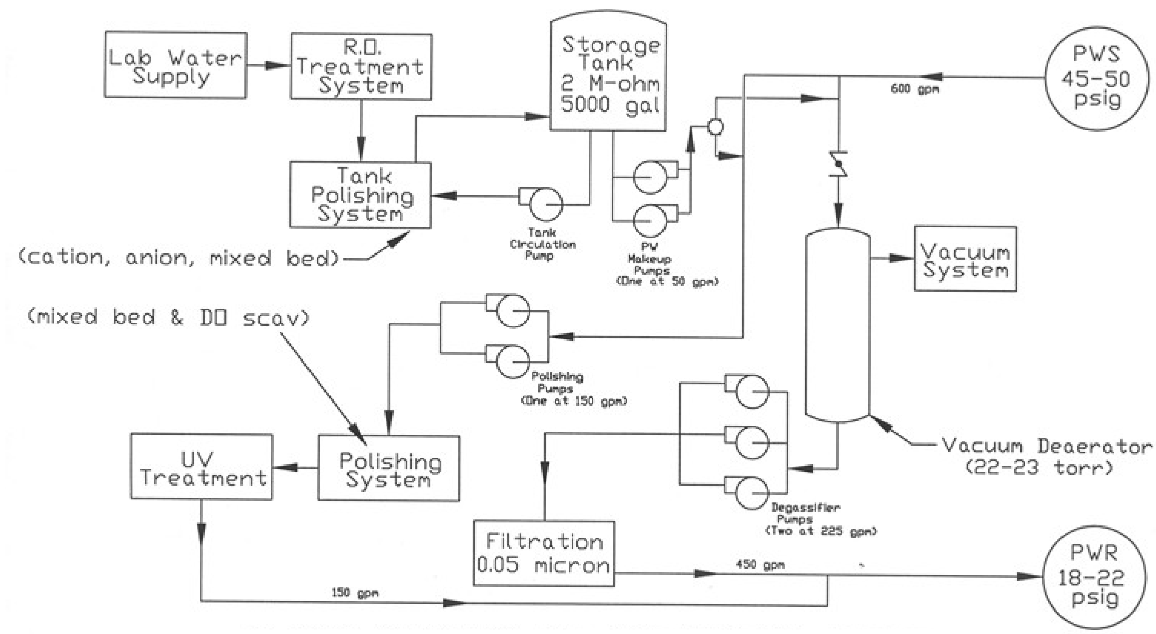

Fig 8: Block Diagram of Polishing System

The degassifier is a 4 feet diameter by 30 feet high tower that is used to remove dissolved gases. A spray nozzle is located at the top of the vessel. A part of the circulating water is brought to the top of the tower by pumps and sprayed down by the nozzle in the form of droplets. Since, the tower is maintained at high vacuum (value), all the dissolved gases separate from the water droplets. The degassed water gets filtered up to 0.5 microns as it through the filter that is located after the degassifier in the primary water circuit.

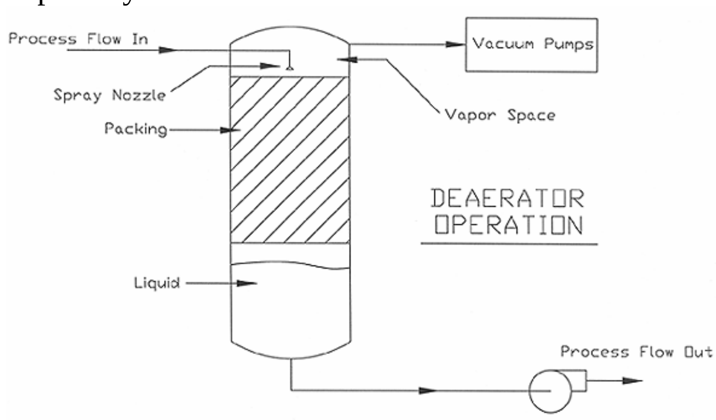

Fig 9: Schematic of the Degassifier

Fig 10: Polishing System - Vacuum Degassifier

The primary purpose of the resin beds is to maintain a very high resistivity or low conductivity by removing all the ions. Two types of resin beds, oxygen scavengers and mixed beds are used. The size of the mixed bed resin is 90 cu. ft on line but net effect is same as 60 cu. ft. UV treatment is performed to remove microbes.

After the polishing process is complete, pH of the water from the primary system becomes very close to neutral (close to 7). The temperature of the water, coming out from the primary water system is 75° F. The maximum dissolved oxygen content is close to 4 ~ 5 ppb and the resistivity is around 8 ~9 MOhm-cm. Water is filtered up to 0.05 microns.

Fig 11: Polishing System – Resins

<u>Secondary Water System:</u>

The secondary water system is located at the mezzanine floor of the Storage Ring (SR). The system consists of twenty secondary pumps that supply cooling water to the forty sectors of the storage ring. One pump supplies water to two sectors. The secondary system supplies water at a precisely controlled temperature of 78° F. The temperatures of cooling water, returning water and water from primary system are 78° F, 81° F and 75° F respectively. This is a PLC controlled system that mixes returning water from the components (81° F) and primary water (75° F) and maintains the cooling water supply temperature at 78° F. This process utilizes the waste heat of returning water by re-circulating it. Depending upon the relative temperature of these three types of water circuits, flow from primary system is regulated by a control valve.

Water temperature varies in different discrete localized zones near the front end and beamline because of various user specific requirements. Additionally, some special equipment specifications require cooling water temperature to be more than 75° F. Each localized system forms one separate loop within the secondary system. These localized loops operate independently without affecting the operation of other loops. Water temperature in various loops varies from 75° F to 90° F while the flow rate varies from 50 to 500 gpm.

Distribution pumps of the primary system supply water to the secondary system at a comparatively lower pressure at 30 psig. The operating pressure of the secondary system water is boosted up to 150 psig.

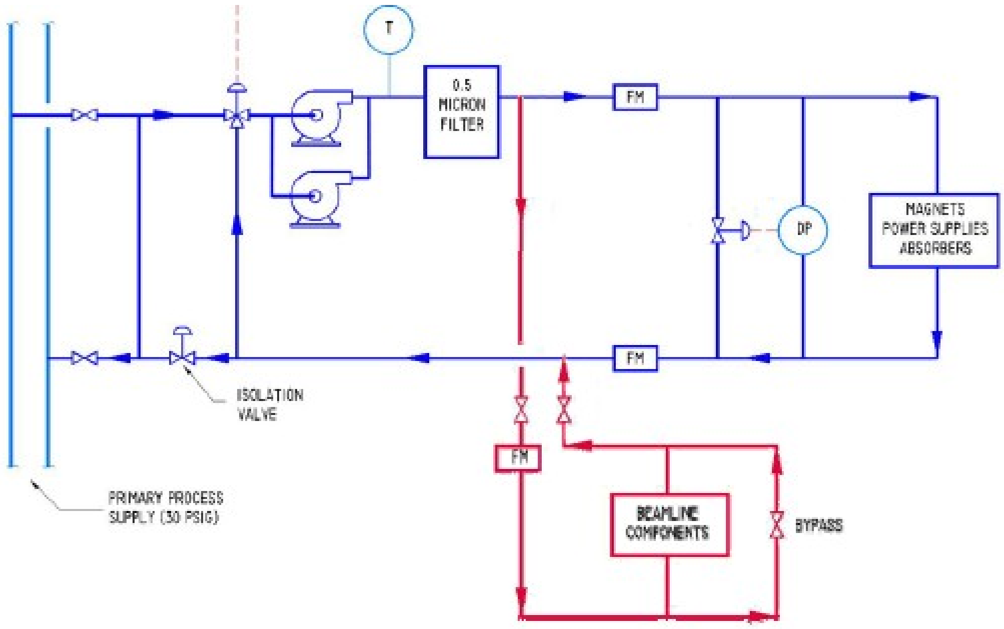

Fig 12: Schematic of Connection of Beamline Components to Secondary Water System

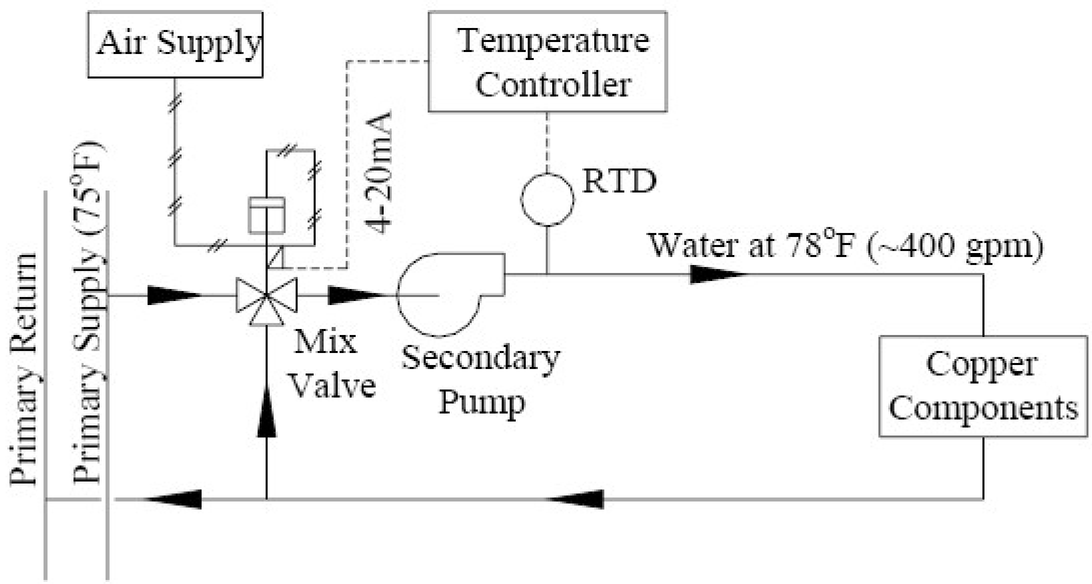

Fig 13: Schematic of Temperature Control by Secondary Mixing

Fig 14: Typical APS Secondary Water System

Fig 15 : One of the Dedicated Beamline User Skid

Water Cooling System for Aluminum Components:

The third cooling system for the aluminum vacuum chamber is divided into twenty cooling skids with each skid containing two pumps. One skid is responsible for supplying water to two of the forty sectors of the storage ring. This system has its own set of dedicated heat exchangers and a temperature controlling system. Chilled water is used to bring down the warm water temperature to 78° F ± 0.05° F. Flow rate is 50 gpm at a supply pressure of 50 psig.

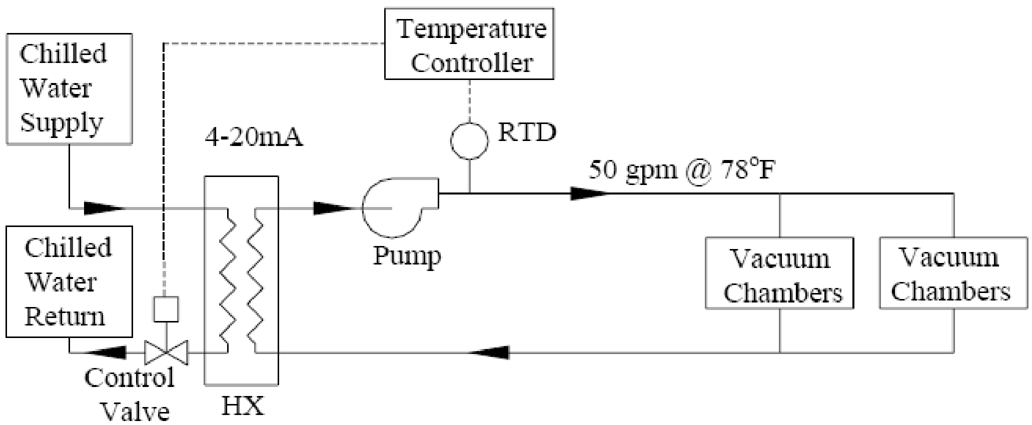

Fig 16: Schematic of Water Cooling System for Aluminum Components

Fig 17: Water Cooling skids for Aluminum Components

Pump capacity
Resin bed
Packing material in the degassifier